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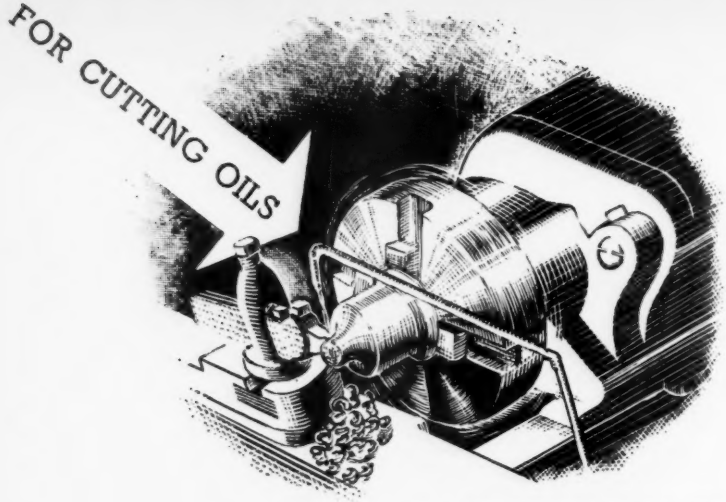

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THE ENGINEERING PRINCIPLES OF THE PRODUCTION OF OIL FROM PETROLEUM RESERVOIRS

By L. C. STEVENS (Fellow)

It will be assumed that the initial exploration well on an anticlinal structure or other suitable geological feature has resulted in the discovery of oil in commercial quantities. It will also be assumed that the structure is entirely covered by the concessions of a single company or by a number of companies who have decided to pool their holdings. In other words, the field will be operated as a unit.

In the first stage of the exploitation of any new field it is essential to obtain certain basic information on which to plan future development. Such important questions as the size of the reservoir, the nature of the reservoir rock, the physical characteristics of the reservoir fluids, the pressure and temperature under which they exist, and the sources of energy available for moving the oil into the well bore and bringing it to the surface, must be answered. This information can only be obtained by drilling and producing an adequate number of appraisal wells and making certain physical measurements.

In the first part of this paper those items of information which should be obtained during this initial appraisal period will be outlined and in the second part their significance in the subsequent exploitation period will be discussed.

PART I

RESERVOIR APPRAISAL

Extent and Shape of the Reservoir

Fig. 1 shows a diagrammatic representation of a simple oilfield reservoir, in plan and in cross section, which will serve to demonstrate certain fundamental concepts.

In planning the appraisal drilling campaign, it is usual to begin with a dip section of wells across the flanks of the structure (i.e., east–west in the illustration) and a strike section towards the plunges. Each successive outstep well may conveniently be located in such a manner than the depth at which it reaches the top of the productive formation will be somewhat higher than the depth at which the previous outstep reached its base. This may not be practicable when the angle of dip is low and outstep distances would be too long. Since the dip of the flanks is usually steeper than that of the plunges, outsteps will usually be closer together down the flanks than along the plunges. After these sections are completed, other appraisal wells may be required at strategic points of the structure to provide information on specific points, for instance fault trends.

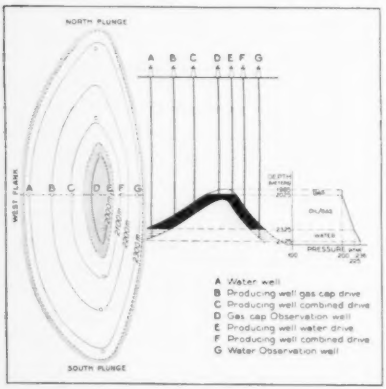

NORTH PLUNGE
A B C D E F G
WEST FLANK
A B C D E F G
SOUTH PLUNGE
A Water well
B Producing well gas cap drive
C Producing well combined drive
D Gas cap Observation well
E Producing well water drive
F Producing well combined drive
G Water Observation well

Fig. 1.

Fig. 2, in contrast to the simplified section of Fig. 1, shows an actual cross section and strike section across a typical oilfield, in this case a limestone reservoir. It illustrates an asymmetric, anticlinal uplift with an important crestal fault and numerous cross faults.

Correlation of the Formations.—In order to determine the shape of the structure, the presence and magnitude of faults, overlaps, thinning of strata, unconformities, etc., it is necessary to be able to correlate the formations from well to well, both above and within the productive zone. The methods available for this purpose are, very briefly: **palaeontology,** usually by means of microforams; **lithology,** by the recognition of some distinctive marker bed or beds; **electric logging,** by recognition of distinctive electrical markers on what is commonly known as a Schlumberger log, which reflects the variations in electrical resistivity and the self potential of the formations penetrated; and **natural gamma ray logs,** showing the variations in the intensity of radioactivity of the formations, which is also frequently characteristic.

Nature of the Reservoir Rock

In order to determine the nature of the productive formations, and also for correlation purposes, geological samples are assembled from all appraisal wells by collecting samples of the drill cuttings returned to the surface in the mud stream, by taking core samples of the formation penetrated with a core barrel run above a special type of bit or with a special device for obtaining samples from the side of the hole after it has been drilled. Additional information can be obtained by the measurement of the rate of bit penetration and by the study of the electrical logs.

Measurements of the porosity and permeability of the reservoir rock are then made on rock samples in the laboratory; this information is particularly

important in the subsequent development of the reservoir.

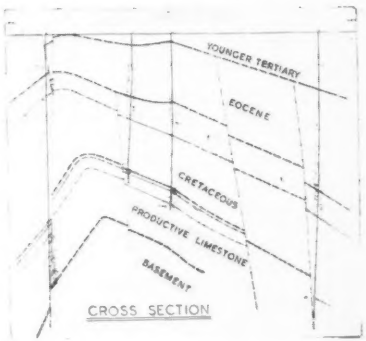
Porosity is a quantitative measure of the storage capacity of the rock. A distinction must be made between absolute and effective porosity. **Absolute porosity** is the percentage relation of the volume of all the pores both *sealed and interconnected* of a rock compared to its bulk volume. **Effective porosity** is the percentage relation of all *interconnected* pores of a rock compared to its bulk volume. Only the effective porosity is available for the production of oil.

In addition to laboratory measurements, which may not be very representative in certain types of formation, e.g., limestone, a comparative idea of the range of porosity can be obtained by examination of drill cuttings under the binocular microscope. In order to obtain larger drill cuttings, suitable for laboratory measurements, the practice of drilling through the productive zone with reversed mud circulation, i.e., down the annulus and up the drill pipe, is often resorted to, particularly in medium to hard formations.

Sand and sandstone layers normally exhibit more consistent porosities of the intergranular type than limestones, which usually show wide variations in porosity over short distances both vertically and horizontally. This will be readily apparent from a consideration of the varying types of porosity found in limestones, both primary porosity, such as intercrystalline, intergranular, oolitic, shell cavities, etc., and secondary porosity, such as jointing, fracturing, solution cavities, dolomitization, etc. Consequently, it is much more difficult to determine the average porosity of a limestone reservoir from observations made on cores or ditch cuttings.

Permeability is that property of a solid which makes possible the transfer or flow of fluids through it; in other words, it is a measure of fluid conductivity. It is not to be confused with porosity although it is related to it in a qualitative sense, namely a solid is permeable by virtue of its interconnected porosity. **A solid body has unit permeability,** called a Darcy, when one cubic centimetre of fluid per second, having a viscosity of one centipoise, travels through an area of one square centimetre of the material under a pressure differential of one atmosphere per centimetre.

In sands and sandstones permeability is governed largely by grain size and the degree of cementation or amount of argillaceous material present in the intergranular interstices.



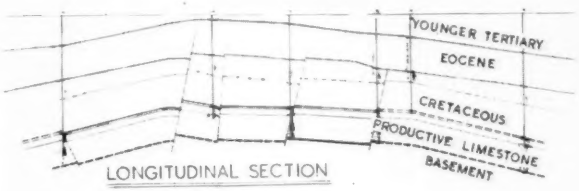


Fig. 2.

The permeability of limestones, being influenced by the fortuitous nature of the porosity, is often extremely variable over relatively short distances in the same formation, and the results of laboratory measurements are frequently not representative of field conditions.

Therefore, it is extremely important for the engineer to observe closely the cores, the ditch cuttings, the drilling speed and, when completed, the production characteristics of every appraisal well, in order to form an early impression of the porosity and permeability of the reservoir as a whole. That is whether it can be considered to have good porosity (large storage capacity), and high permeability (a good degree of fluid conductivity), or whether these factors are of a low order, resulting in what is usually described as a "tight formation".

Physical Characteristics of the Reservoir Fluids

In every petroleum reservoir, gas, oil, and water are found in association. While water is usually found below the oil, in addition, a certain amount is almost invariably present in the oil zone itself. This is commonly known as **"connate water".** Since the majority of sedimentary rocks are deposited in water, their pore space contains water until it is displaced by oil; a certain amount of this water adheres permanently around the contact points between the grains or, in the case of a non-granular rock, in the finer interstices. The amount of connate water can be determined from core analysis, preferably using cores taken in an oil-base mud, by a study of the Schlumberger resistivity log, or by capillarity studies. The amount of this connate water must be subtracted from the porosity when calculating the storage space available for oil.

Gas occurs in solution in the oil and to a smaller degree in the water. If the oil is fully saturated with gas under the prevailing reservoir pressure, any excess gas will occur in the form of a free gas cap located in the apex of the structure or against fault seals, pinch-outs, and unconformable overlaps.

The height of the oil column. The appraisal wells will also serve to determine the *height of the oil column*; this is the common term for the vertical interval from the gas/oil contact, or, if there is no gas cap, the apex of the structure, to the oil/water contact. Since the oil column is frequently several times the thickness of the productive layer, a number of successive dip outsteps may be required before the water level is encountered. If the discovery well was not located on or near to the apex of the structure, it may be necessary to drill one or more specially located wells in order to determine whether there is an original gas cap and if so, its extent (see Fig. 1).

The saturation pressure of the reservoir crude or "bubble point" is defined as that pressure at which the first bubble of gas is evolved from solution from the reservoir liquid under the prevailing reservoir temperature. If there is a free gas cap, it will correspond closely to the reservoir pressure at the gas/oil interface. It changes with temperature which in a deep oil column may vary considerably. Therefore, in order to decide whether the quality of the reservoir fluid is uniform over the structure, which is not always the case, the saturation pressure of the reservoir fluid from various wells should be correlated at one standard temperature, corresponding to a convenient datum plane in the reservoir.

The saturation pressure can be measured in the laboratory, either by recombining the oil and gas from a suitable well in the production ratio, or by taking a sample of the reservoir fluid from the bottom of a well, and expanding it in a pressure cell. Samples should be taken early in the life of the well (and

reservoir) before free gas is present around the well bore. As will be shown later, it is of fundamental importance in connexion with the exploitation policy of the field.

From the same samples other important physical characteristics of the oil/gas mixture should be determined, such as the *compressibility of the reservoir liquid* at pressures above the saturation point, the *gas volume liberated* from the oil at various pressures below saturation pressure, the change in volume or *shrinkage* of the liquid phase, due to the evolution of gas, on reduction of pressure; the *gas expansion factor*, that is, the volume occupied by the evolved gas under reservoir temperature and pressure, compared to its volume under standard conditions; and *the variation in viscosity of the reservoir liquid* with pressure. Measurements are usually made at the reservoir temperature at mid oil column or other agreed datum. In addition the reservoir fluid is flashed through a separator under different conditions (pressure and temperature) in order to investigate the total shrinkage to tank conditions, the specific gravity of the resulting tank oil, the corresponding gas/oil ratio, etc.

Fig. 3 shows the relation between total volume, also the oil volume (bubble point liquid = 1), and pressure of a typical reservoir crude from which several of the above factors can be deduced.

Static Reservoir Pressures and Temperatures

In all reservoir engineering calculations, it is most important to have an accurate knowledge of the original static reservoir pressure and temperature. These vary with depth and must therefore be referred to a particular depth in the well or to a selected datum plane in the reservoir. The original static pressure should be measured in the discovery well before any appreciable amount of production is extracted. Subsequently measurements should be made of the closed-in pressure in all new wells on their completion and at regular intervals in a reasonable amount of the producing wells. These periodic surveys will serve to determine the rate of change of the closed-in reservoir pressure with production, to ascertain whether new wells have initial pressures related to the reservoir average, indicating whether they are in good pressure communication, and to check whether all producing wells show a reasonably uniform rate of pressure decline.

Production Characteristics of the Reservoir

Turning from the physical parameters of the reservoir and its contained fluids to the dynamic side of the production of oil, it is also necessary to determine the characteristics of the reservoir from the angle of fluids in motion.

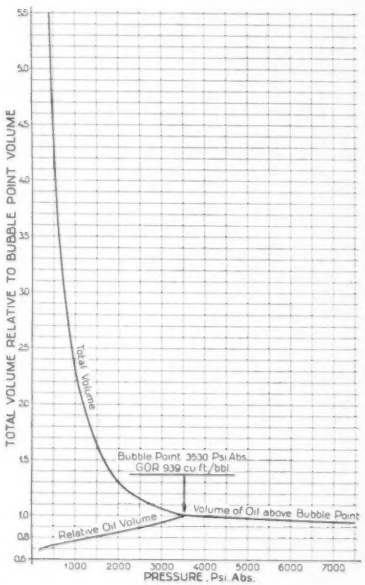


Fig. 3.

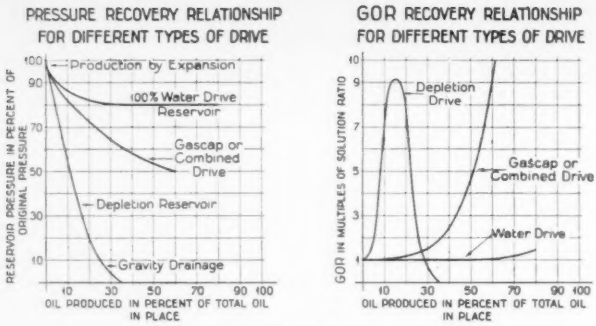


Fig. 4.

Considering the various sources of energy available for bringing the oil to the well bore and for raising it to the surface, these are:

1. The expansion energy of the reservoir liquid with falling pressure, when this is above the saturation pressure;
2. The expansion energy of the gas evolved from solution in the reservoir liquid, when the prevailing pressure drops below the saturation pressure;
3. The expansion energy of any free gas originally in the reservoir on reduction of pressure;
4. The hydrostatic pressure of the edge water acting below the oil column;
5. The force of gravity causing the drainage of oil from higher points in the reservoir to wells situated at a lower elevation.

In any particular field at least one, and probably more than one of the above sources of energy will be available and whichever predominates will determine the production characteristics of the reservoir. The predominating source of energy may change at different stages in the productive history of the field.

The most common terms to describe the various types of reservoir control are usually as follows:

(*a*). **Production by liquid expansion**—*this can only occur in a reservoir where the crude was originally undersaturated. Due to the relatively small coefficient of expansion of the reservoir liquid, it is characterized by rapid drop in pressure compared to volume of oil produced and ceases when the saturation pressure is reached. Thus it occupies only a relatively short period in the early life of any field.*

(*b*). **Production by depletion**—*when a new well is placed on production, the pressure in the well bore when flowing drops below the prevailing static reservoir pressure, setting up a differential pressure under which flow of oil into the well can take place; this is called the* "bottom hole differential flowing pressure", *or more simply the* "drawdown". *Once the flowing pressure in a producing well drops below the saturation pressure, gas will be evolved in the formation surrounding the well bore, producing what is commonly known as a cone of depletion. This depletion cone will expand with continued production, unless sources of energy other than that of the expansion of the solution gas are available to replenish it. A reservoir with this characteristic is known as a* depletion type field, *sometimes called a* "dissolved gas drive".

Production and reservoir pressure will decline with time and the gas oil ratio will increase rapidly until the oil is largely denuded of gas, and control eventually changes to gravitational drainage. The wells will only flow by natural pressure for a limited proportion of their life and artificial means of lifting the oil to the surface will then be required.

(*c*). **Production by general motion**—*in fields where water moves into the reservoir space voided by oil, due either to the expansion of the edge water body or to outcrop replenishment, also where*

there is an original gas cap or where a secondary gas cap has formed, due to the gas liberated from solution having migrated into the apex of the structure, then the depletion cones of the wells may remain of constant size or expand slowly, being replenished by liquid flowing into the cone at the same rate or almost the same rate as the well's production. This replenishment is due to the general motion of fluids in the reservoir under the influence of one or more of the above sources of energy. The reservoir is then said to have either a "water drive" *or* "gas cap drive", *or, if both are almost equally effective, it may be spoken of as a* "combined drive". *Reservoir pressure will fall relatively slowly or, in the case of a water drive, after an initial drop, may remain constant. Gas/oil ratios will remain close to solution ratio, provided the gas cap is not allowed to blow through. Production rates will be well sustained and artificial lift may not be necessary. In practice, many reservoirs prove to have a partial water drive or partial gas cap drive. In other words rate of production would be too slow, and consequently uneconomic, if oil were produced at such a rate that the water drive could maintain the reservoir pressure close to the original; some controlled rate of reservoir pressure decline is therefore accepted in order to allow a greater rate of offtake.*

(*d*). **Production by gravity drainage**—*this will only be of important significance in the later stages of the life of a depleted reservoir. Its method of operation has already been mentioned under* (5) *above.*

Fig. 4 shows typical reservoir pressure-production relationships and gas oil ratio-production relationships for the various types of reservoir drive described above.

U.N. CONFERENCE ON RESOURCES

The provisional programme of the United Nations Conference on the conservation and utilization of resources, May 16 to June 3, 1949, shows that the search for, and increased production of, petroleum, will be discussed at one of the plenary meetings.

Petroleum will figure largely in the meetings in the fuels section with half-day sessions devoted to techniques of discovery, to techniques of production, and to secondary recovery. The sessions on synthetics will include discussions on natural gas synthesis, liquid hydrocarbons from coal, and oil from shale; while under utilization it is planned to deal with the economics of competitive fuels, the use of oil for other than fuel purposes, etc.

U.K. CRUDE OIL OUTPUT

Total production of crude oil during 1947 from the oilfields of the Anglo-Iranian Oil Co. Ltd. in the United Kingdom was 47,200 tons.

IMPERIAL COLLEGE OF SCIENCE VACATION WORK SCHEME

An abstract from the Thirteenth Annual Report to the Governors of the Imperial College of Science shows rapidly increasing and successful progress in that College's scheme for the placing of British students during their vacations in works abroad, and in exchange, the placing of foreign students similarly in Britain. In 1947, over a hundred British students in total were so received in works in Belgium, Czechoslovakia, Denmark, Finland, France, Holland, Norway, Sweden and Switzerland, while about the same number from these countries were found similar posts here. Effective operation of the scheme began in 1946; subsequent placings and registrations both show its rapid development.

Among the petroleum companies actively associated with the work are: Esso Development Co. Ltd., Limmer and Trinidad Lake Asphalt Co. Ltd., National Oil Refineries Ltd., "Shell" Refining & Marketing Co. Ltd., and the N.V. de Bataafsche Petroleum Mij.

COUNCIL COMMENTARY

THERE was a fairly good attendance of Council members on May 12 for the first meeting of the new session following the election of new members. The new President, Mr E. A. Evans, extended a warm welcome to the new members and at the same time expressed his appreciation of the services of both Mr G. H. Coxon and Mr Hugh C. Tett, who had occupied the position of Chairman of Council during the presidency of Sir Andrew Agnew. On his proposal, Council extended a hearty vote of thanks to both. Mr Tett, in replying, welcomed the new president and also took the opportunity of expressing his thanks to the Hon. Secretary for the work done during Mr Tett's period of office as Chairman of Council.

These pleasant but sincere formalities over, the Minutes of the April meeting were read, approved, and signed after slight correction. Matters arising from the Minutes were then dealt with.

A letter of appreciation was read from Dr G. M. Lees in reply to our letter of congratulation on his being made a Fellow of the Royal Society.

The President reported a meeting of the Petroleum Industry Standards Committee on April 29 at which Messrs. L. C. Burroughs and J. G. Detwiler of the A.S.T.M. and Messrs. E. L. Garton and H. Hyams of our Institute were also present. It was agreed that the A.S.T.M. and the Institute of Petroleum should jointly encourage the adoption of international standards.

After discussion, the President signified his willingness to give a paper to the Association Française des Techniciens du Pétrole.

Mr Thornton reported that a meeting of the Education Committee had been held, but it had not been possible to arrange a joint meeting with the Election Committee as instructed at the previous Council meeting. The position with regard to the City and Guilds' new courses and examinations, however, was urgent and required Council approval. These examinations had been prepared at our request and without assistance, with the intention that they should be an acceptable qualification. The larger question of whether examinations should be part of a qualification for Associate Fellowship had already been decided in principle when this work was undertaken and, though it might not be expedient at this stage to insist on examinations, and this one in particular, as compulsory for candidates applying for Associate Fellowship, it was desirable that this or some other suitable examination should have recognition from the Institute of Petroleum in order to encourage technical institutes to offer preparatory courses. After considerable discussion, the necessary approval of these examinations as part technical qualification for Associate Fellowship was given, Council further expressing approval of the suggestion that industrial organizations should encourage their staffs to obtain such qualification.

The report of the Finance Committee was presented by the Chairman, Mr G. H. Coxon, and the audited accounts for the year ended December 31, 1946, were tabled. It was decided to hold the adjourned 34th Annual General Meeting on June 9 to deal with these accounts, which were approved. It was stated that the 1947 accounts were complete but awaited the auditors, there being no possibility that they also could be ready for this June meeting.

The Branches' report was submitted by Mr Thornley who drew attention to the growing membership of the Branches and to the Northern Branch suggestion that membership should be confined to corporate members of the Institute. This is a procedure not favoured by all Branches, and decision must depend on local circumstances rather than Council direction.

Report E.234 was dealt with by Mr E. J. Dunstan, the Deputy Chairman of the Election Committee. Attention was drawn to the fact that names submitted in this particular report, had only just appeared in the *Journal* that very day and had not, therefore, been available to members for a sufficient length of time. In view of this, discussion of the report was held over until the next meeting of Council. Comments were made concerning the decisions of the Election Committee in certain cases and Council members were asked to send their observations to the Election Committee for consideration.

Each year the composition and membership of Council Committees comes up for review, and this year the President and Hon. Secretary were asked to prepare recommendations for the consideration of the Chairmen of such Committees and the approval of Council in due course.

Mr C. A. P. Southwell, on behalf of the House Committee, presented a report on a meeting held on April 20 and this was approved.

In qualification of the remark made in the last Commentary that the Council was substantially the same, there did seem to be quite an appreciable number of new faces around the Council table at this meeting, which is all to the good and should strengthen the Committees and, in general, infuse new ideas and new energy into the Council as a whole. Certainly, the Council now contains a fairly good representation of the many-sided interests of the industry.

PERSONAL NOTES

F. H. Braybrook, F.Inst.Pet., has been appointed a member of the Panel on Imports Substitution of the Committee on Industrial Productivity recently set up by the British Government.

Dr J. E. Smith, M.Inst.Pet., has recently left Trinidad on leave and is to be transferred to Venezuela. Consequently he has resigned from the Chairmanship of the Trinidad Branch, and *P. E. T. O'Connor*, A.M.Inst.Pet., has been elected Chairman for the remainder of the current session.

P. T. Cox, M.Inst.Pet., has been appointed deputy general fields manager to the Anglo-Iranian Oil Co. Since October 1946 he has been manager of the Petroleum Division, Masjid-i-Sulaiman.

Included in the King's Birthday Honours were: *H. E. G. West* (Knight), director of National Benzole Co. Ltd.; *H. H. Green* (O.B.E.), assistant fields manager, Iraq Petroleum Co. Ltd., Kirkuk; *J. B. Clark* (M.B.E.), manager, Steel Bros. & Co. Ltd., Haifa.

G. W. Halse, M.Inst.Pet., has recently left Trinidad on a visit to England.

H. G. Kugler, F.Inst.Pet., is leaving Trinidad shortly for a visit to England and probably to Switzerland. Subsequently he will be taking up residence in Caracas.

E. G. C. Mardall, F.Inst.Pet., left Trinidad early in June on a business trip to the U.K. He was travelling in the tanker *Regent Hawk*.

EMPIRE MINING & METALLURGICAL CONGRESS

The Fourth Empire Mining and Metallurgical Congress is to be held during July 9–23, 1949, with an Inaugural Meeting in London, technical sessions in Oxford, and excursions based for the most part on provincial universities.

ECONOMIC UTILIZATION OF FUEL OIL IN BOILER AND INDUSTRIAL FURNACES*

By ARNOLD PEARCE

FUEL OIL BURNING EQUIPMENT

For industrial purposes there are on the market many reputable types of burner employing a number of methods for procuring atomization of the oil, but fundamentally differing very little in principle. Burners will be chosen to suit the particular requirements of the process, and the more general types are:

(1) Mechanical atomizing,
(2) Steam or medium pressure air atomizing,
(3) Low pressure air atomizing,
(4) Rotary.

For steam generation on a big scale the mechanical atomizing burner is, in the main, the most popular type, but for furnace work in general and burning of heavy oils where there is no external source of power the steam, or medium and low pressure air jet, type has obviously some advantages. With this type of burner, flame control is good, and for steel manufacture (soaking pits, mill and reheating furnaces, etc.) this type of burner is very popular.

For the higher outputs required with open hearth furnaces good burner performance is not entirely essential as high furnace temperatures ensure complete combustion of the oil, even if atomization is not perfect. Here it is preferable that atomization should take place at the rear end of the burner so that danger from carbonizing of the burner is reduced. For industrial applications where steam is not available the low or medium pressure air atomizing burner is a good type to install and is very simple in operation.

Examples of the various types of oil burner which are available are shown in Figs. 1 to 5.

Mechanical or pressure atomizing burners can be designed to burn from 150 lb to 6000 lb hour or higher. The chief disadvantage is that without changing tips the range of capacity is somewhat limited, but by employing the constant differential method of fuel control, which is a device for maintaining a substantially constant difference in pressure between the supply of oil to the burners and return oil from the burners, it is possible to ensure efficient atomization over a wide range of output (see Fig. 6). For satisfactory operation with straight mechanical atomization a pressure range of about 2 : 1 corresponding to a capacity range of 100 to 60 per cent is somewhere near the limit.

By changing burner tips the normal type of mechanical atomizing burner can be made to operate quite satisfactorily over the whole range. But where load changes are fairly rapid then cutting

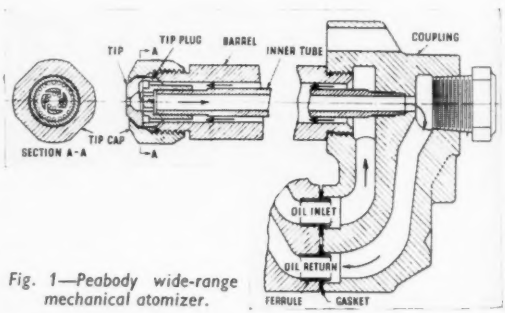


Fig. 1—Peabody wide-range mechanical atomizer.

* Continued from page 173.

in and out of burners cannot be obviated.

For high outputs, forced draught pressures of the order of 2 to 5 inches water gauge may be necessary. With natural draught the maximum burner capacity is probably about 800 lb/hour, depending on the available stack draught.

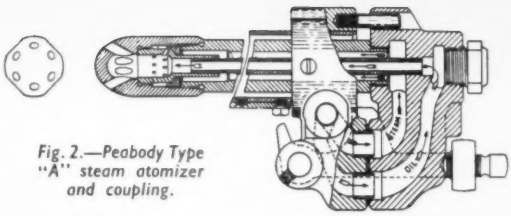


Fig. 2.—Peabody Type "A" steam atomizer and coupling.

An oil fuel system employing the return system (see Fig. 7) is particularly useful where the oil is of indifferent quality and waxy distillates (with tendency to solidify) are being burnt. Constant circulation assists in keeping the system clear by preventing the tendency of such oils to solidify in the cooler portions of the pipelines, and is worth the slight expenditure of additional power.

Steam atomization has some advantages in that a wide control of output is possible without the need for all the above ancillary plant. Where conservation of feed water is necessary, as in power stations or in marine practice, the steam atomizing unit is unsuitable.

The steam atomizer may require a supply of steam from 1·5 to 3 per cent of the total boiler evaporation at full output which, on large units, can be quite considerable. The Americans claim to have designed steam atomizers requiring only 1 to 1·5 per cent.

The low pressure and medium pressure air atomizing type of burner can be successfully employed for the smaller plants. Moreover, in the case of the latter type, a failure of the air supply may put the burner out of action, but if steam is available this may be used for atomization at the same pressure as air.

A comparison between efficiency and capacity for mechanical and steam atomizing burners is given in Fig. 8.

With heavier fuel oil the steam atomizing burner may have advantages over the mechanical atomizing unit.

Nevertheless, the use of steam should, if possible, be avoided as every pound of steam used for atomizing the oil involves the throwing away of about 1000 B.Th.U. which is lost in the flue gases. Flame temperature is reduced also.

With a suitably designed burner, medium pressure air at, say, 10 to 15 p.s.i. gauge should give as good results as steam if the fuel oil is up to standard quality. On the other hand, where a wide range of flame control is unnecessary ordinary pressure atomization is satisfactory.

In general, air atomizing burners may be divided into three main classes:

(1) Low pressure air, 0·5 to 1·5 p.s.i.
(2) Medium „ „ 1·5 to 15 p.s.i.
(3) High „ „ 15 to 150 p.s.i.

The higher the air pressure the less air will be required for atomization. Thus, for a burner using air at 80 p.s.i. only about 2·5 per cent of the combustion air will be required for atomization, while with a burner operating on low pressure

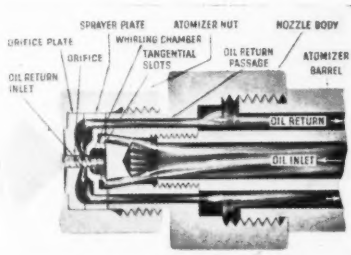


Fig. 3.—Todd mechanical atomizer.

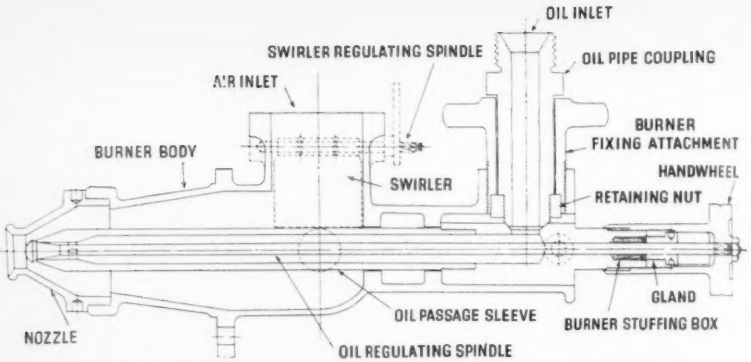


Fig. 4.—Wallsend low air pressure system. Section of regulated swirl type burner.

air at 20 inch water gauge at least 25 per cent of the combustion air may be required for atomization.

In certain processes where high temperatures are required, the low pressure air burner may be at a disadvantage since air pre-heat temperatures for all air passing through burners should not exceed 500° F, thus limiting the capacity of recuperators and regenerators.

With high pressure air, since the quantities of air required for atomization are so small, there is no limitation to the pre-heat temperature.

Combination or alternative fuel type of burners can be designed to burn either oil, gas, or pulverized coal, but the most frequent adaptation is the combination gas-oil burner, as pulverized coal is best dealt with in a burner designed solely for burning this fuel.

A combination gas-oil burner is shown in Fig. 9. In general, it is preferable to burn gas or oil separately. A number of types of gas burners can be employed. Some of these may be of the gun type, but if the ring type is properly installed and orifices kept clear, this is undoubtedly the best type for boiler firing.

An interesting type of burner is shown in Fig. 10, and has been developed primarily for furnace work, and for obtaining a wide degree of flame control. It has features incorporating flexibility, simplicity, and control over the rate of combustion, and some details are:

(1) Size—10/40 therms hr (55 to 215 lb/hr. oil),

(2) Turn down ratio—4:1 gas and 5:5 oil,

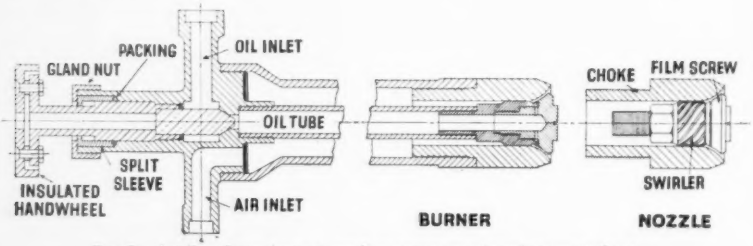


Fig. 5.—Laidlaw Drew burner, medium pressure air and steam jet system.

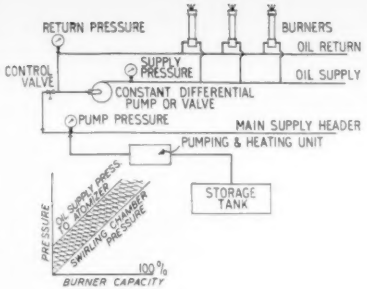


Fig. 6.—Peabody constant differential system.

(3) Combustion air pressure—up to 6 inch w.g.,

(4) Gas pressure—0·4 to 0·0 inch w.g., short to long flame respectively.

(5) Oil pressure—up to 16 p.s.i.,

(6) Air atomizing pressure—up to 25 p.s.i.

The atomizing steam consumption is roughly 0·25 to 0·45 lb/lb of oil, or with atomizing air about 0·3 to 0·5 lb/lb of oil.

It is claimed that combustion can be controlled to within 0·5 to 1 per cent of the maximum theoretical CO_2. The above should meet the requirements of metallurgical furnaces ideally, but for boiler operations the chief disadvantage is the relatively high air pressure required so that increase in fan power may be considerable for larger size burners.

To sum up, therefore, so far as burners are concerned the tendency will be to develop these so that heavier oils can be employed for industrial purposes, reserving the light distillates for prime movers or very sensitive automatic burners, as employed for domestic purposes.

For large-scale uses with burners of suitable design and proper combustion chamber proportions there should not be much difference between results obtained on straight run or catalytically cracked fuels.

Disadvantages associated with aromatic fuels may be to some extent offset (in metallurgical and ceramic industries) by increased emissivity of flame, and this factor has a lot to do with the economy in fuel consumption obtained. Burners employed in these industries may be designed to give coarse atomization to prolong combustion.

On account of increased flame luminosity of creosote pitch this is sometimes preferred to higher grade fuel oils. The whole problem of flame luminosity is somewhat indefinite, but furnace operators are well aware that a fuel which gives luminous flames tends to have a greater heating capacity and better transfer than if fired with non-luminous flames.

In furnaces requiring fine atomization (as in boilers) and short flames, it is not always good policy to employ larger burners rather than a greater number of smaller ones, but the arrangement of the burners has a big influence on this. This applies particularly to pressure atomization for which the range of control is somewhat limited. In this field the steam or air blast burner may give equally good results and allow use of fuels of lower grade.

Experiments on the Continent indicate that the rotary type of burner has some advantages for certain purposes and allows a wide range of fuels to be successfully burnt. Results indicated

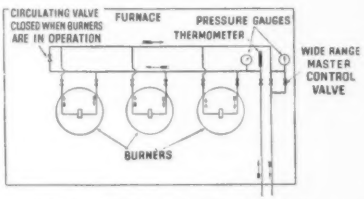


Fig. 7.—Constant circulation system.

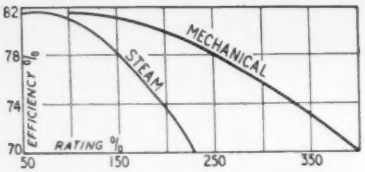


Fig. 8.—Efficiency capacity curves for mechanical and steam atomizing burners.

that design of the burner register and quarl has some bearing on flame stability.

WASTE FUELS

Another important field is the burning of waste fuels, acid tars, sludges, bottoms, etc., which is quite a problem in the refining industry.

This, however, opens up wide prospects for experiment and has the great advantage of enabling the industries to burn fuels of lower grade than normally supplied. With acid tar burners some success has been obtained by employing hard carbon tips, but being of a brittle nature fracture during cleaning is the main problem. Tungsten carbide is an answer to this problem, but it is both difficult to obtain and very expensive. Experiments are continuing with burning these tars, but due to other troubles associated with high acid content it does not appear that atomization and burning in the ordinary way is the best method. A typical analysis of acid tar is:

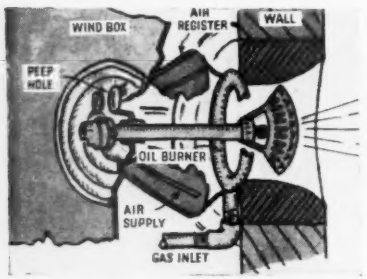


Fig. 9.—Combination gas/oil burner with ring type burner.

Vicosity, Redwood I at 100° F sec ...	200 (variable)
Ash, per cent	0·2
Volatile matter, per cent	76
Total sulphur, per cent	13·5
Free acid, mg H_2SO_4 gm	330
Gross calorific value, B.Th.U.	9,616

At times these tars may contain nearly 30 per cent free acid.

It is important to remember that developments in burners should be in line with the requirements of the available fuels as concentration on one type of burner to burn one given fuel may create a scarcity and thus embarrass the suppliers. Developments should rather take place in designing burners to deal with a wide range of fuels.

ANCILLARY EQUIPMENT

Apart from the atomizing equipment there are other essential components, such as:

(1) Storage and transfer pumps,
(2) Pumping, heating, and filtration plant, which can be provided in a complete unit,
(3) Pipelines.

It is not proposed to give more than cursory mention to these as there is plenty of literature describing them.

On the matter of storage, it is preferable to have in stock about a fortnight or three weeks' supply of oil, and two tanks are better than one for storage since one can be used as a settling tank. It may be necessary to provide heating facilities to keep oil sufficiently fluid for pumping, and a steam trace on the oil line may be desirable, particularly in cold weather and in exposed positions.

On large systems continuous circulation of the oil has some obvious advantages. Pipelines should be of ample proportions, with hot oil lines always lagged, and the distance from burners at a minimum.

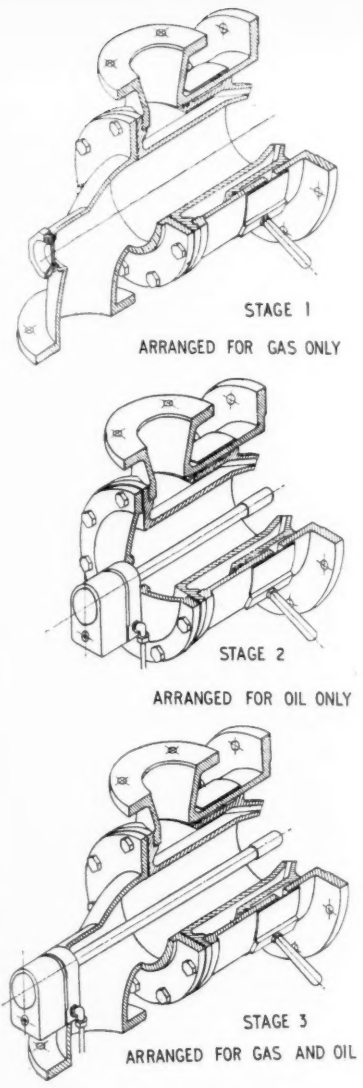


Fig. 10.—Wellman-Smith "Universal" burner.

Positive pumping of the oil is preferable to gravity feeds where oil may flow from an overhead tank to the burners, and this system should not be employed except for the smaller installations. Tank heating may be done by steam coils or electric immersion heaters, and these should preferably be thermostatically controlled.

Provision of suitable heating arrangements is very important, and temperature control should be within close limits so that the oil reaches the burners at the right temperature for atomization.

(*To be concluded*)

THE INSTITUTE OF THE MOTOR INDUSTRY

THE Second Summer School of The Institute of the Motor Industry is to be held at St. Catharine's College, Cambridge, from August 21 to September 3, in two periods (Aug. 21–27 and Aug. 28–Sept. 3). The school is intended primarily for those in executive and responsible positions, its object being to provide for intensive study of various aspects of the industry. A few vacancies have been reserved for non-members of the Institute employed in the motor industry. The inclusive fee is £10 10s. for one week.

A Residential Course for works managers and foremen on the subject of Problems of Presentation of Information in the Motor Industry has also been organized for the period August 21–28.

SOUTH WALES BRANCH

On May 7, 1948, a paper was read by Mr Millien on "The Manufacture of Waxes by the Solvent Process."

Mr Millien, who is a member of Sunbury Research Staff of the Anglo-Iranian Oil Co., presented information, illustrated by lantern slides, on the modern production of waxes by use of solvents. Samples were displayed.

DISTRIBUTION OF PETROLEUM PRODUCTS

On January 2, a meeting of the South Wales Branch was addressed by R. E. Adlington (Member), Distribution Engineer, Anglo-Iranian Oil Co., on the subject of "Development of Engineering Equipment for Distribution of Petroleum Products."

The subject was dealt with on the basis of storage, transportation and redistribution of all grades of petroleum products by land, water, and air. The equipment was described in its early and its present-day forms, and future developments were indicated.

In addition to the familiar types of steel storage tanks, the steel-lined concrete tanks captured from the Italians in North Africa and Eritrea were described, also the "Hydrowall" water-sealed type of concrete tank for storage of light products. Modern vapour recovery systems using balloon roofs, "vapour spheres" and gasholder type liquid-sealed roofs were mentioned, also various types of hemispheroids for prolonged storage of aviation gasoline.

Land transportation by road tankers and rail tank cars was mentioned, also the pump and pipeline method used so successfully by the Allies, not only for base installations, but also for feeding our advancing armies with "P.O.L.", as far forward as possible.

Sea transportation, from barges to the latest ocean-going tankers, was briefly reviewed, whilst mention was made of the transport of petroleum products by air, with special reference to the feeding of forward airfields during the war, and the possibilities of tanker aircraft in the future.

After a brief reference to the conventional equipment used for redistribution of heavy oils and motor spirit on land, the rapid progress being made in regard to aircraft fuelling was outlined at some length. The advent of underwing or pressure fuelling to give rapid fuelling rates was described, also the provision of fine particle filtration for fuels used in the modern jet and direct-injection aircraft engines.

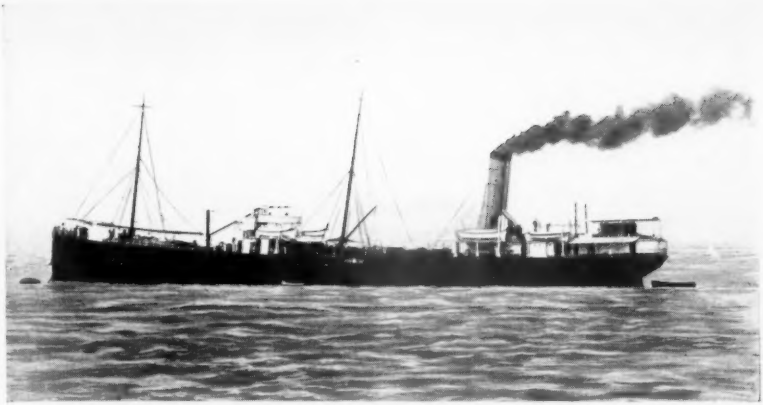
The launches used for fuelling seaplanes and the latest fuelling bays used at seaplane terminals were described, and the talk concluded with a detailed description of "flight refuelling" which was initiated by Sir Alan Cobham in 1937 and which is rapidly becoming an "every day" operation for long-distance flights where maximum payloads and elimination of intermediate stops for fuelling are of primary importance.

The talk was illustrated by a large number of coloured pictures, projected by epidiascope, and an interesting discussion followed.

In reply to a vote of thanks by E. Thornton, who took the chair in the absence of R. B. Southall, Mr Adlington assured those present that it had given him the greatest pleasure to re-visit Llandarcy where he had "served his apprenticeship" in the petroleum industry over 20 years ago, and to meet so many old friends again.

THE FIRST OIL WELL?

In a recent talk before the Alaska Section, American Institute of Mining and Metallurgical Engineers, William Foran, petroleum geologist, stated that Nebuchadnezzar had an oil well dug in the Near East around 700 B.C. and even before that time Hammurabi set forth requirements for building, as concerned the amount of asphalt that must be used in mortaring bricks. The discovery of the ancient oil well was made by an American oil party which reported that the well had probably been dug by hundreds of subjects of the king and had been lined with alabaster. —*Mining and Metallurgy, May* 1948.



THEN AND NOW

S.S. "Volute" (above), a vessel of 5670 tons deadweight, with a speed of 9 knots, was built in 1893, only one year after "Murex", the first Shell tanker, went into service. In 1900 "Volute" was converted into an oil-burning vessel thus becoming the first tanker in the Shell fleet to burn oil. The oil used was Borneo crude and was full of leaves, twigs and other foreign bodies.

T.E.S. "Hyalina" (below), a recent addition to the Shell fleet, is a tanker of 18,000 tons deadweight with a service speed of 16 knots. Equipped, as is her sister ship "Helicina", with diesel-electric mechanism, the power developed is the greatest ever borne in merchant ships by single shaft. A feature of this vessel is that every member of the crew, even the most humble, has his own comfortably furnished cabin.

Photos by courtesy of Shell Petroleum Co., Ltd.

PETROLEUM IN PARLIAMENT

Hydrocarbon Oil Duties

The Chancellor of the Exchequer said in a written reply on May 31 that the amount of hydrocarbon oils retained for home consumption and the net amount received in respect of duty thereon during the year ended March 31, 1948, was:

G.P.O. Petrol Consumption

The Postmaster-General stated on June 2 that the quantity of petrol used by his department during the first quarter of 1948 was 3,436,000 gallons. The comparable figure for 1947 was 3,362,000 gallons, for 1946 it was 2,655,000 gallons and for 1938 was 2,274,000 gallons.

Description (*a*)	Approximate quantity of duty paid oils retained for consumption	Approximate net receipts	Fully rebateable oils (*b*)
Light oils—	Thousand gallons	£1,000	Thousand gallons
Petroleum spirit—			
Motor spirit	1,281,769	48,066	—
Other spirit	44,415	1,666	—
Coal-tar products—			
Benzol	—	—	—
Other sorts	30	1	—
Turpentine	1,078	40	—
Heavy oils for mixing with light oils (*c*)	12	—	—
Other hydrocarbon oils	387	15	—
Oils in composite articles	46	2	—
TOTAL, LIGHT OILS	1,327,737	49,790	—
Heavy oils for use as fuel in road vehicles (duty-paid at rate for light oils)	175,295	6,574	—
Other heavy oils (duty-paid at 1d. per gallon)—			
Petroleum oil—			
Crude oil	2	—	63
Kerosine	177,247	739	285,211
Lubricating oil	133,899	558	4,768
Gas oil	14,201	59	357,127
Fuel oil	14,679	61	837,371
Other sorts	2,527	10	6,687
Coal tar products	(*d*) — 24	—	—
Other oils	50	—	2,070
Oils in composite articles	98	—	41
Gases produced from imported heavy oils	76	—	100
TOTAL, HEAVY OILS other than road fuel	342,755	1,427	1,493,438
TOTAL, DUTIABLE OILS	1,845,787	57,791	—
Deduct net amount paid to Isle of Man, etc. (*e*)	—	313	—
	1,845,787	57,478	—

(*a*) The descriptions of oil correspond with those used in Customs documents, but are not defined by statute.

(*b*) These quantities of oils fully rebated under Section 1 of the Finance Act, 1947, are quantities delivered out of official charge without payment of duty, whether or not subsequently exported.

(*c*) Dutiable as light oils.

(*d*) Excess of repayments.

(*e*) Difference between amounts collected in, and allocated to, the Isle of Man, during the year ending March 31, 1948, and allowances under Section 8 (4) of the Finance (No. 2) Act, 1945.

Haifa Shipments

The Parliamentary Secretary to the Ministry of Fuel and Power said on June 1 that the oil tanks at Haifa had not been emptied, but that intermittent pumpings of crude oil down the pipeline were being made and that shipments were taking place as opportunity occurred.

Heysham Refinery

In a written reply on June 8 the Minister of Supply stated that the refinery section of what the questioner termed "the £10 million plant erected during the war for the production of aviation fuel" was sold to secure the best use of the plant in the national interest. About one-half of the plant in the hydrogenation section was being used for the production of ammonia, and in the remainder, pilot production of methanol had recently been started.

U.K. Oil Production

The output of liquid products from home-produced crude petroleum and shale oil during the year ended March 31, 1948, was 35·3 million gallons, which represents 1 per cent of our consumption, said the Minister of Fuel & Power on June 10.

CATALYTIC CRACKING MODEL

This working model of the fluid catalytic cracking process has been designed by Universal Oil Products Co. as a demonstration unit. Air takes the place of oil vapour as the catalyst carrier from regenerator to reactor and steam in the stripper, but the operation of the fluid solids technique can be readily simulated. Cyclones attached to the reactor and the regenerator can also be seen removing catalyst from the vapours. The model may be seen in operation at the company's new offices in Bush House, Aldwych, London, W.C.2.

LONDON BRANCH VISIT VAUXHALL MOTORS

On the morning of Wednesday, May 19, in blazing sunshine, some 30 members of the London Branch left Victoria by coach to visit the Vauxhall Motor Works at Luton.

Immediately on arrival the visitors were made to feel "at home" by the Vauxhall reception staff, who assembled them at The Vauxhall Exhibition, gave the day's plan of action and then led them off to a welcome eleven o'clock coffee in the staff restaurant.

Returning to the Exhibition, members saw the five hundredth thousand Bedford commercial vehicle produced, and were informed that were these 500,000 lorries placed nose to tail they would stretch from London to Bagdad! A large volume of information—technical and non-technical—was set out in an attractive shop-window fashion for all to see. This gave the shipping and transport people amongst the visitors food for thought and even the least covetous folk a healthy desire to possess a shining new Vauxhall motor car.

After an excellent lunch, provided by the company, members were split into parties, each under a guide who explained as much of the vast works as possible in the time available. The machining and processing of components proved to be most interesting and to see major assemblies such as rear axles, engines and gearboxes, etc., taking shape was a fascinating experience.

Members were much impressed by the process of stamping out the body panels, and the vast presses which transformed flat steel sheets into shapely wings. In the hands of the welders, working amid showers of sparks, the various pressed parts were assembled into recognizable forms.

Finally, the conveyor belts were followed through the workshops. Here was the last word in organization as hundreds of parts from small nuts to complete bodies were fitted into the skeleton chassis frames which grew in 1 hour and 40 minutes into finished substantial lorries, or elegant cars. The remarkable team spirit that kept the production lines running smoothly was much admired.

A full and interesting day concluded pleasantly with tea provided in the special visitors' mess. The Branch Vice-Chairman, Mr H. G. Spence, proposed a vote of thanks. Members' appreciation was clearly shown by their acclamation and Mr Lemon, responding for Vauxhall Motors Ltd., kindly extended an invitation to a further visit.—A. L.

MINISTRY OF FUEL AND POWER

Dr H. Roxbee Cox, M.I.Mech.E., F.R.Ae.S., has been appointed to be chief scientist at the Ministry of Fuel & Power. He is at present director of the National Gas Turbine Establishment.

Sir Alfred Egerton, F.R.S., Professor of Chemical Technology at the Imperial College of Science and secretary of the Royal Society, has accepted the invitation to be chairman of the Scientific Advisory Council set up to advise the Minister on the scientific aspect of problems connected with the development of coal petroleum, and other sources of fuel and power in Great Britain, and of promoting economy and efficiency in the supply, distribution, use, and consumption of fuel and power. The Council will also advise on new developments and keep under continuous review the whole field of fuel and power.

Membership of the Council includes Professor F. H. Garner, O.B.E., F.Inst.Pet., and Sir Harry R. Ricardo, F.R.S., Hon. M.Inst.Pet.

BRITISH EQUIPMENT FOR MIDDLE EAST OIL

SPEAKING in London recently to nearly 250 members and guests of the Council of British Manufacturers of Petroleum Equipment, Mr H. A. Hammick (Iraq Petroleum Co.) told them that, from the present rate of, roughly, £58 million per annum, purchases of material and equipment in Britain by British oil companies for overseas should, if the problem of supply were tackled in earnest, rise to £100 million or more in a year or so.

To facilitate discussion of the Report issued by the Chairman and Vice-Chairman of the Council (Mr S. T. Robson and Mr E. F. E. Howard), following their tour of Middle East oil centres last autumn, the Council arranged meetings in London and Glasgow during April, which were marked by speeches of special interest from oil company speakers who included Mr H. A. Hammick, Lt.-Col. S. J. M. Auld (Vacuum Oil Co.) and Mr R. C. Thomson (Anglo-Iranian Oil Co.).

Both Mr Hammick, speaking to the London meeting, and Col. Auld, speaking to the Glasgow members, stressed the importance of "the enormous change that has taken place in the problems of producing and distributing oil in the last few years" since "from being the chief world provider of petroleum products, the United States was now so extensively importing oil—mostly of course as crude—that she is at present on the verge of becoming a net oil importer". Mr Hammick quoted the oil companies operating in the Middle East as planning to ship to and through the Mediterranean "a total of some 80 million tons per annum—20 times as much as in 1939," adding that this meant the equivalent in heat units of more than half the total production of coal in the United Kingdom.

On the question of where this oil would be consumed, Col. Auld suggested that, with the United States satisfying her own requirements and the Middle East supplying Europe and much of the rest of the world, "the active oil centre of the world is moving into Europe", adding, "Need we hesitate to say that the natural centre is here in our own country?"

As the speakers pointed out, this immediately raised the question of the necessary equipment and especially of refinery capacity and here Mr R. C. Thomson gave the Glasgow meeting some striking figures in illustration of what the estimated expenditure of £95 million in the next five years on refinery development in Britain means in categories of equipment.

Finally, oil company and Council speakers combined in emphasizing that, if British industry is to seize the opportunity offered to it now, it must devote to the needs of the oil industry the same specialized attention as is given to the coal, woollen, steel, printing, and other similar industries all of which have groups of manufacturers whose whole function for many years has been to provide equipment for them. It must be recognized that the oil industry was at the present time the most important single purchasing industry in Britain, and that its demands were primarily for export and of a long-term nature. Moreover, it should be remembered that, behind the capital expenditure, there was very considerable expenditure on maintenance and spares, apart from the constant replacement of equipment rendered obsolescent by the unceasing development of the processes involved.

A GAVEL FOR TRINIDAD

At the last annual dinner of the Trinidad Branch, Mr L. A. Bushe noted that the chairman had to use a pepper pot to call for attention. He has now rectified this by presenting the Branch with a gavel and block.

OIL INDICATIONS

By J. S. PARKER (Fellow)

Oil seepages, mud volcanoes, and pitch lakes are all well-known indications of the presence of oil. There are other indications which are not so well known. One of these is the presence of balls of blue clay.

Years ago the story went the rounds that when a well-known American oil-man named Doheny was rampaging around the Gulf Coast he kicked a ball of blue clay. He recollected that similar

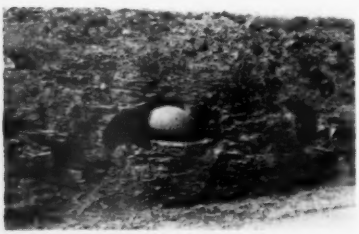


Fig. 1.—Blue ball exposed in cut made for main road to the new Los Organos field.

clay balls were present on one of his producing fields. On this slender evidence he initiated drilling operations which eventuated in a new producing field.

This interested me at the time and later I noted further evidence of the same feature. The Lobitos house flag is comprised of three blue balls in pyramidal form on yellow. The yellow is symbolic of sand and the blue balls are symbolic of the balls of blue clay.

Lately, whilst in Peru, I was interested in checking the appearance of these blue balls. The first noted was in a cut made for a road linking up El Alto with a new field being developed at Los Organos about ten miles farther north. A photograph of this ball in the actual geological formation is shown in Fig. 1.

On noting my interest my guide stated that when we got back to Lobitos the tide would probably be out sufficiently for further blue ball photographs.

In the late afternoon we drove to the last Lobitos well to the south, walked a further half-mile over dry desert, and arrived on the beach south of Punta Lobos.

Traversing the beach one thought one was seeing things, the beach was moving. The beach was one solid mass of small crabs all scurrying hither and thither at the sound of each footfall.

A short walk north along the beach brought us to Punta Lobos where the action of the sea has removed the softer formation leaving a crop of blue balls fully exposed. A photograph of these is shown in Fig. 2.

On a small rise adjacent to these blue balls the first well in Peru was drilled. Though the well has long since been abandoned the derrick supports and the top of the well are still visible. Fig. 3 shows this oil well site. It will be noted that the supports are of stones held together by cement mortar. Cement was not easily obtainable in these parts in these pioneering days.

Fig. 2.—At low tide, blue balls are exposed on the beach at Punta Lobos.

Fig. 3.—Blue balls at Punta Lobos at the site of the first oil well drilled in Peru.

One wonders at the condition of Doheny's toes after he had kicked one of these blue balls.

WORLD CRUDE OIL OUTPUT

The 1947 report of the N. V. Koninklijke Nederlandsche Maatschappij tot Exploitatie van Petroleumbronnen in Nederlandsch-Indie (Royal Dutch Company for the Working of Petroleum Wells in the Netherlands Indies) gives the following figures for the world's production of crude oil, including natural gasoline:

	In 1000 metric tons		In 1000 barrels	
	1947	1946	1947	1946
United States	266,495	248,157	1,988,110	1,849,680
Venezuela	63,364	56,684	435,120	388,720
U.S.S.R. (incl. Sakhalin)*	27,100	22,800	197,600	166,200
Iran	20,500	19,497	155,000	146,520
Saudi Arabia	12,208	8,145	89,850	59,940
Mexico	8,088	7,090	56,460	49,390
Iraq	4,721	4,713	35,370	35,300
Roumania	3,929	4,388	28,920	32,290
Colombia	3,542	3,186	25,700	22,110
Argentina	3,133	2,984	21,910	20,870
Trinidad	3,018	2,972	20,520	20,210
Kuwait	2,225	813	16,230	5,930
Brit. Borneo	1,826	296	12,970	2,050
Peru	1,794	1,769	13,700	13,510
Bahrein	1,287	1,096	9,410	8,010
Egypt	1,337	1,278	9,360	8,940
Neth. E. Indies	1,119	302	8,020	2,100
Canada	1,020	984	7,730	7,610
Austria	928	846	6,220	5,670
Hungary	570	685	4,380	5,270
Germany	577	646	4,040	4,520
Ecuador	319	320	2,400	2,410
India	257	248	1,910	1,880
Netherlands	213	63	1,480	440
Other countries	875	789	6,300	5,670
Total	430,445	390,751	3,158,710	2,865,240

* Estimated

THE BENEVOLENT FUND

THE Benevolent Fund of the Institute has recently received the sum of £33 6s. 8d. from the Trinidad Branch as their donations for the years 1946 and 1947. In the Report of the Branch for 1947 it is stated:

> *Benevolent Fund.*—During the year the sum of $77.50 was received in contributions from members of the Trinidad Branch. Contributions by Trinidad Branch Members have fallen off considerably during the past years and the Committee wishes to commend this most deserving cause to all members (a drive is to be made to augment the Branch's contributions towards this fund).

The Chairman (Dr A. E. Dunstan) of the Benevolent Fund writes: "Members of Institute will be interested in the valiant effort made by the Trinidad Branch to support the Benevolent Fund. It may even come as a surprise to some of our more recently-elected colleagues that such a Fund exists. At the moment it has a credit balance of about £2,700. Fortunately, there have been but a few calls upon it in recent years, but it is vastly important to build up a solid reserve on which the Institute can call in cases of real need.

"I need hardly do more than commend to the attention of all members the extremely fine example of Trinidad—*verb. sap.*

"Just as I write a welcome gift of five guineas has arrived from a distinguished Fellow who prefers to remain anonymous."

INDUSTRIAL CHEMISTRY CONGRESS

The 21st Congress of Industrial Chemistry, organized by the Société de Chimie Industrielle and the Federation des Industries Chimiques de Belgique, will be held in Brussels, September 12–19, 1948. There will be 23 sections arranged in seven main groups and full details are available from the offices of the Congress at 28, rue Saint-Dominique, Paris (VII^{e}).

JAMES YOUNG—FOUNDER OF THE MINERAL OIL INDUSTRY*

By EDWIN M. BAILEY (Member)

Let us now trace Young's training and career as an industrial chemist, and the influences and friendships that helped to mould his character and life.

He was born in the Drygate, near the cathedral, in the east end of Glasgow, on July 13, 1811. His father was John Young, a working joiner and cabinet-maker, who married Jean Wilson. James got an elementary education at the parochial school. At an early age he was apprenticed to his father in his shop at 91 Kirk Street, Calton—often the only assistant. He attended evening classes in mechanics, chemistry, and other subjects and enrolled as a pupil in the Mechanics' Institute. At the evening classes at Anderson's College, he attracted the notice of Thomas Graham, Professor of Chemistry, who found him very useful in constructing apparatus and assisting in his lecture experiments. Young became assistant to Prof Wilson in the natural philosophy class and in 1832, at the age of 21, he left his father's workshop and devoted himself entirely to scientific study, being appointed assistant to Prof Graham. While at Anderson's college he met, as fellow-students or pupils, young men who later became famous—David Livingstone, Lyon Playfair, and James and William Thomson (Lord Kelvin), all of whom he instructed in handicraft.

In the *London and Edinburgh Philosophical Magazine and Journal of Science*, April 1837, there appears a long "communication" by "Mr James Young, Chemical Assistant in the Andersonian University". An Account of a new Voltaic Battery, being a modification of the construction recommended by Mr Faraday (with figures). "The existence of a defect is fully admitted by Mr Faraday in the construction which he recommends." (Young's is quite a long paper.)

In 1837 Prof Graham was appointed to University College, London, and he took Young with him as assistant. On May 6 of that year, Graham wrote, when absent from London: "In case I remain here, would you make a point of seeing Mr Young and request him to begin the practical course."

Graham's influence over Young was an important factor in his future career. Dr Angus Smith says: "Graham's direct influence was exercised in a manner which I rather think may be called quite new. . . . His pupils wanted work, and he gave them his to do. . . . The work on water of crystallization was all done in these early days at the Andersonian University whilst Graham himself sat looking at the fire, too lanquid even to look at the experiments." Smith names two other chemists who taught in that laboratory of whom Glasgow might be proud—Dr Stenhouse, famous in botanical chemistry, and Mr John Thom of Chorley, who in reality did the experiments on which were based the theories of constitutional and saline water.

Graham and Young worked well together and entered jointly into many original researches. Young showed scarcely less facility than his master, and his lifelong devotion to Graham was a tribute to how much he owed to him during the 11½ years when they worked together, receiving as he did a thorough training in pure chemistry and experimental research.

T. E. Thorpe, in his "Graham" Lecture (1894) says that Young was

* Continued from page 183.

"one of Graham's discoveries, and for a long time in Glasgow and London, one of his most trusted associates, and he enabled me to hear much of Graham's personal character and mode of work. When one considers the amount and character of work Graham got through, the influence it must have had upon Young cannot be estimated." (*Memories and Portraits of* 100 *Glasgow Men*, Maclehose, 1886.)

In J. H. Gladstone's *Life of Faraday*, he says: "Mr James Young, who was in the laboratory of University College in 1838, thus writes: 'About that time Prof Graham had got from Paris Thilorier's apparatus for obtaining liquid and solid carbonic acid; hearing of this, Mr Faraday came to Graham's laboratory and showed great interest in this apparatus, and asked Graham for the loan of it for a Friday evening lecture at the Royal Institution, which of course Graham readily granted, and Faraday asked me to come down to the Institution and give him the benefit of my experience in charging and working the apparatus. so I spent a long evening at the Royal Institution laboratory. There was no one present but Faraday, Anderson and myself. The principal thing we did was to charge the apparatus and work with the solid carbonic acid, Mr Faraday working with great activity; his motions were wonderfuliy rapid, and if he had to cross the laboratory for anything, he *ran* for it, and when he wanted anything he spoke quickly." ' It was in this year, August 21, 1838, that Young married his cousin, Mary Young.

In 1839, on Graham's recommendation, Young was appointed chemist at the chemical works, erected in 1823, of James Muspratt (the founder of the South Lancashire alkali industry) at Newton-in-the-Willows, St. Helens, near Liverpool. Later, Young was appointed works manager; his management was most successful, not merely in the yield and quality of products, but in avoiding nuisance or injury to neighbouring estates.

In 1843 he removed to Manchester as Manager of the Ardwick Chemical Works of Charles Tennant, where in 1847 he discovered the process for obtaining oil from coal, and where he improved the manufacture of solid caustic soda, and produced Prussiate of Potash. There is a "Subscriber's Ticket" of membership of Manchester Mechanics' Institution—"Admit Mr J. Young. No. 2869, September 29–December 25, 1844."

Young's life in Manchester during the next few years was full of activity, interest and variety, as the following extracts show, for which we are chiefly indebted to *A Century of Science in Manchester* and *The Life and Works of Thomas Graham*, both by Dr R. Angus Smith.

"James Young, who was a member of the Literary and Philosophical Society of Manchester (elected October 19, 1847) wished to have a chemical society and brought together about thirty young men connected with works; they, or at least some of them, met in summer in country places, had tea at an inn generally, and held their meetings at the tea-table. Some of the meetings were very pleasant. It was afterwards connected with the Literary and Philosophical Society itself, forming the first section; the addition of several sections took place afterwards. Most of the members were chemists in works." The Society comprised many distinguished names in science as honorary members; in the list of those elected in 1843 are Dalton, Faraday, and Humbolt; and previously those of Priestley, Lavoisier, Benjamin Franklin, Erasmus Darwin, and Josiah Wedgwood.

Young began another movement in Manchester. He was a Liberal in politics, and did not consider the *Manchester Guardian* sufficiently so, and he was the means of starting the *Manchester Examiner and Times*. While

in Manchester he had a large circle of friends. He renewed his acquaintance with Lyon Playfair, who had drawn his attention to the spring of oil in Derbyshire, and when Tennants allowed him to work it he put it under the care of Edward Meldrum, one of his assistant chemists. When starting his works at Bathgate in 1850, he took Meldrum into partnership along with Edward William Binney, a Manchester solicitor, who was a well-known geologist and author of 134 papers, and who has left a fine collection of geological specimens.

Young's friendships were loyal and enduring. Graham, Playfair, and Angus Smith were his friends indeed; and there were others. In 1881, Dr Young of Kelly, put in order, and leased to Rev. Dr W. B. Robertson, of Irvine, on easy terms, the mansion of the little estate of Westfield, in Midlothian, which he had acquired for the sake of its oil-yielding minerals. In 1880, he took Dr Robertson on a cruise in his yacht among the Hebrides, along with Prof Wm. and Mrs Thomson. When in Florence in 1877, Robertson was commissioned by Young to buy pictures of old masters for a collection he was trying to form. But of all his friends, none was closer than David Livingstone, missionary and explorer of "Darkest Africa." A mass of details is available from various sources, but I name only a few. At Anderson's College Young, taught Livingstone "how to use his hands"; the great explorer called the River Young after him; "Sir Paraffin Young's great Lualaba River; the western branch I have named the Young River to commemorate my early instructor in chemistry and life-long friend"; writing at sea Livingstone says, "The whole 2000 miles has been an everlasting see-saw, and enough to try the patience of even a chemist, who is the most patient of all animals"; at a meeting of the Royal Geographical Society in London in 1873, Sir Bartle Frere referred to an expedition sent to Africa in search of Livingstone, "the expenses being defrayed by Dr Livingstone's noble-minded friend, Mr J. Young, of Kelly"; in the *Manchester Examiner and Times*, May 15, 1873, it is stated that "Young has contributed with an open hand towards the establishment of mission stations on the Victoria Nyanza"; and one who knew him well has said that "Young manifested a tenacious and abiding loyalty in his friendships—a depth and steadiness of affection under all his natural reserve."

Young was elected a Fellow of the Royal Society in 1873; and LL.D. was conferred on him by St Andrews University in 1879; on his retiral in 1870 he founded and endowed the "Young" Chair of Technical Chemistry at Anderson's College, Glasgow; and was President of the College from 1868 to 1877. He was Vice-President of the Chemical Society 1879–81. He was a Justice of the Peace for Midlothian.

He bought the estates of "Durris" in Aberdeenshire, and "Kelly" near Wemyss Bay in Renfrewshire, and so became known as "Dr James Young of Kelly". His products obtained a prize at the International Exhibition in 1851; he had exhibits in Paris in 1855; he displayed 6½ tons of paraffin wax at the Industrial Exhibition of 1862; exhibited at Dublin in 1865; and at the exhibition in France in 1867 he was awarded a gold medal for his splendid display.

We may now try to gain some idea of the *personality* of James Young in youth and in maturity. It has been said that "The true diarist writes for no audience other than himself", and such a diary may give us the truest picture of the writer. Through the kindness of Dr Young's grand-daughter, Miss Thom of Limefield, West Calder, I have had access to some diaries and scrap-books kept by him, and from these valuable, authentic, and interesting sources have been selected some passages that illustrate in a vivid way his personality in youth and manhood:

May 5, 1830 (age 19). *I got up at half-past four. I began to Mr Wotherspoon's counter which I am to do for* £1. *My father got an order this day to make a coffin for an old woman which he was to do for* £1. *He got* 10*s. when he went up with the board; he is to get the remainder in three weeks. I went to the river this night. I am now in vulgar fractions.*

On the 9, *Sabbath, I got up about* 5 *and went with Mr Wilson to walk. I went to church this day and heard Professor Taylor preaching, and at night I went and heard Mr Harvie of the Relief meeting house, Kirk Street.*

12. *This day I went with Mr Parlane to see two men execute* (sic).

On 15 *I got up at half-past four. . . . I sent Janet to the library with Paley's* Evidences for Christianity *and Murray's* Africa, *when I got back Paley's with insect architecture.*

On 20 *I got up about* 5. *I finished the counter this day for which I charged* 22*s.* 6*d., but I did not get the money.*

On Sabbath the 6 *I went to Church in the forenoon and heard Mr Turnbull and to the Tron Church at night. On the* 7 *I got up about* 5, *polished the varnish of* 2 *snuff boxes, went with my father to McCallum's for part of the wood for two basin stands, in the forenoon put in a head board for Mr Cart, wrought from five till near* 10 *with the basin stands. This night the cock died.*

On the 8 *got up about* 4 *and turned a pair of stumps for my brother, wrought some at the basin stands, put a board on fleming's* (sic) *press for Miss Stobo and took off* 2 *locks, and put a board in a window at Moor Street. On the* 5 *I got up about* 5. *I wrought little on account of a sore tooth which got taken out about* 8 *o'clock.*

On the 8 *I went to see Mr Green's baloon* (sic) *which was to go off at three from the cattle market.*

Oct. 9 *I went in the evening to see an exhibition at the foot of Salt Market. I saw* 2 *crocodiles from the Nile and an alagater* (sic) *from St domingo* (sic) *with* 2 *serpents, the crocodiles were about* 3 *feet long as I gessed* (sic) *and the alagater* 4.

On Sabbath 11 *I got up about* 7 *as I had slept so long that I did not wake.* (*At church forenoon and afternoon.*)

On 13 *I went about* 5 *o'clock to a colection* (sic) *of wild beasts. I agreed with the keeper for a ride on an elephant so I got mounted on its nek* (sic), *it kneeled down till I got on and to let me off. It took my bonnet off my head and put it on the keeper, fired a blunderbuss, showed its foot and did other tricks at the word of the keeper.*

29. *This morning I bought a thermometer and in the evening I went and heard a lecture on anatomy by Mr Hunter.*

On Sabbath 1 *August I got up about* 6 *o'clock and went with James Wilson out Cathcart road. . . . In the forenoon Mr Mushet preached and in the afternoon Mr Turnbull. In the evening I went to the Tron church and heard Mr Gammie.*

On the 2 *I was at the chair, on* 3 *I was at the chair, on the* 4 *I finished the chair and went to see boat races on the Clyde and after I came home repaired some bakehouse drawers for Mr Weir.*

On the 6 *I went to see a Ventriloquist. On Sabbath* 8 *I got up about* ½ *past* 5, *took some bitters for my stomac* (sic) *as I had taken some the night before which was the first I had taken. I went to the church in the forenoon, at night I went to the Tabernacle. On the* 10 *I started for Belfast and got there on the* 11 *and left it on the* 12 *and got home on the* 13. *On the* 7 *I got* 1 *dozen eggs at Cathkin.* 25. *On this day two of the chickens came out, the first came out at* 9 *o'clock was black, the other which was white came out at* 2. *Oct.* 10. *I went with my brother to Clyde Iron Work. I did not go to church this day on account of a sore eye which I had.* 27. *George went to the infant school this day. I found about* 5 *o'clock morning one chicken out, white with a black spot on the back of the head. At* 6 *I found two more out and at* 7 *another, at* 9 *I found a speckled one, at* 10 *I found a dark one. at one I found a speckled one.*

On 22 *I bought guy's* (sic) *geography and pinock's catechism for* 1*s.* 7½*d.*

Nov. 8. *To mechanics' institution and heard Mr Mackie on Natural Philosophy. On* 10 *I went in the evening to hear Mr Heron's interesting lecture in the Anderson University. On* 11 *I went in the evening and heard Mr Wilson lecture on Mathematics in the Anderson University. On* 13 *I was at the chairs and went and heard Mr Graham. On* 16 *I was at the lecture at night and got* 2 *books. On* 27 *I was trying to make a lectifying* (sic) *machine and we got a lecture from Mr Maconnachy. On the* 28 *I was turning vases for bees.*

On 22 *we had a visit from James Black and as I was with him in the town we met our cousin Mary.* (*His future wife was a cousin Mary.*) *On* 7 *I got* 1½ *lb zinc to make a galvanic pile. On* 8 *the pile was in action. On Sabbath* 9 *I was at church and at school. On* 22 *I bought a bottle to make an electrical machine and tried the protoxide of nitrogen.*

On Feb. 3 *we had no work. On the* 4 *I made* 5 *panels for practising painting.* (*This is very interesting as Young, like John Dalton from whose name is derived the term "daltonism" for the defect, was colour-blind. For this reason he was fond of statuary in his house rather than pictures.*)

On 5 *I was producing hydrogen gas by the*

galvanic pile and by the action of sulphuric acid with iron and water. On 7 Mr Mcconnachy began his anatomy lectures and I attended the first one . . . we had little to do all this week. On 26 I was making a mouse house for Mr Marguis. On 28 I was at the mouse house. On 1 March I was at the mouse house, 12s. On 2 I went and heard Graham lecture and went to dobbies loan (sic) *to see printing.*

On 6, 7, 8, 9, 10, 11—"we had little to do". On 20 I went to seek a job but did not get it".

Young prided himself on his workmanship as a cabinet-maker. In 1859, Graham, in a letter, refers to a cabinet which "if not a very handsome, I believe is a substantial piece of carpentry as Mr Young used to pride himself on it, particularly on the hinges of the lower compartments, which are of his own invention."

His note-book—"James Young, Glasgow, 1835. Irish"—gives a very full account of his visit to Dublin for the meetings of the British Association. Here are some condensed glimpses of his many racy pictures:

"A fine ship—some rare boys in the boat—boiled ham and buttered toast, very good—curious thing the phosphorescence of the sea—by using metallic stuffing £50 a year is saved for grease alone." (Of the beggars on the road)—"rare fun with the boys here, 'Leave me one half-penny and the blessing of God go with ye; oh, leave me one half-penny to a poor cratur for the love o' God'—plenty of fun the whole way, from Belfast to Dublin by coach. . . . Dublin is a good-looking town but built of brick . . . the natives are good speakers—every beast of burden in Dublin must trot if it does not gallop, cuddys and horses all the same —we saw soda water labrotary (*sic*) on a sign—coals at Dublin 10 - per ton."

Then follow notes of points discussed at the meetings, with comments by Young:

"Dalton gave his views of the atomic constitution of gases; Davy discussed comparative (*sic*) value of Irish and Virginian tobbaco (*sic*)."

Of another speaker Young says: "The safety of Davy's lamp is doubted by this person, he allows all the fault to the workmen, the meeting generally thought the lamp quite safe if rightly used. Mr Graham on hydration of salts, he got off well. Dalton tried to do Graham and posed him pretty well. Dr Reid on sound, walls ought to be rough and low, roof low and of wood, floor rough. At 4 o'clock to Zoological Gardens, few animals of note but they appear to be clean and comfortable. Went to Rotunda at night, Dr. Lardner on application of steam, house was crowded with Fashion."

In the same note-book, dated 1835, is what appears to be Young's reply to the presentation of a watch by the Mechanics' Class: "My dreams have been realized. You have formed a mechanics' class which for numbers has seldom been equalled, and what is far better for diligence stands unrivalled. There, Sir, may be seen the mechanics who come to spend their evenings at the fountain of science and I have no doubt but many who now attend the mechanics' class will soon shine forth by applying their knowledge for the benefit and comfort of their species. . . . I would ask who are these that make Nature give up her secrets; you will say it is the diligent and persevering philosopher."

Here are entries in later note-books:

1846. *"Scenery of the Heavens" by Dick. Ginger beer and fruit 5d. Bed and breakfast 2s, dinner 10d., Toys 6d., Slate 6d., Theatre 1s. 2d., Bed 1s., Breakfast 7d., Blouse 7d., Books 16s., Fruit 4d., Book 4s. 6d., Toys 1s., Ale 6d., Ginger beer 2d.*

1847. *Rabbits, plants, tea, umbrellas, brooch. Bromine exists in the salt springs of Cheshire. Scott's novels 30 and upwards, Chambers' Cyclopaedia 17 and upwards.*

1846. *James Young, Alkali Cottage, Newton. Send for saddle bridle and drawings. Pease draft, 1 quart. Radish 3d., carrots 3d., lettuce 3d., parsley seed 2d., cress 2d. Wrote to Wilson about Reichenbach's papers on tar. Send to Alfreton 6 beakers 13 oz.,*

12 *Florence flasks, 3 hydrometer tubes, 8 tierces Stannate as before.*

1850. *Read Prof Christison on the petroleum of Rangoon and discovery of parraphins* (sic).

1851. *J. Young, Longsight Terrace, Manchester. "The Rainbow or Ladies' Pocket Book and Almanack for* 1851", *price* 1*s.* 6*d. Parrot coal* 30 *tons* £20. *Fuel* 40 *tons* £7. *Vitriol* 1 *ton* £6. *Told Mr Statham that I intended to receive no salary from this date. Try the soluability* (sic) *of precipitated peroxide of tin in nitric acid.*

Feb. 1, 1866. *Talked to Mr Creath of mining by machinery. He is to get all information and study the matter. No.* 7 *pit to be started to-morrow.*

May 8. *Strike of retort men at Addiewell for* 1*s. a week and stop at* 2 *o'clock on Saturdays.*

May 10. *At exhibition of Pictures in Glasgow.*

May 19. *At Edinburgh at opening of Industrial Museum.*

1867:

Apr. 8. *Went to Preston.*
9. *Went to London.*
12. *Went to Paris.*
14. *Palm Sunday. South Kirk.*
21. *Easter Sunday. Kirk.*
22. *Chemical dinner.*

May 10. *Went to Edinburgh with Nicholson and had a row with lawyers about railway money.*

Sept. 21. *Was at meeting of managers of Andersonian for first time. Promised* £1000 *to get rid of debt.*

Oct. 28. *"Saw Bridges Adams about burning oil for heat; went with him to see Wenham's engine; it seems the germ of a great thing."*

Nov. 5. *Went to Edinburgh and saw Dr Sir J. Y. Simpson.*

Nov. 12. *Shooting rabbits at Kelly with Thom. Good sport.*

Nov. 21. *Kelly. R. Thom came. Bartholomew shot deer.*

Nov. 24. *West Calder Kirk.*

Dec. 1. *Midcalder Church.*

Dec. 19. *Lord Torphichen's dinner.*

,, 21. *Unwell.*

,, 23. *Unwell.*

,, 24. *Unwell.*

,, *In bed. Dr Watson with me. Compound rhubarb pill did the trick.*

1868:

Jan. 4. *Edinburgh, theatre.*

Oct. 8. *Foundation Stone.*

Nov. 3. *Heard Bright speak in Music Hall. Dined with Pender.*

(To be continued)

IRAN OIL PRODUCTION

Crude oil production in Iran by the Anglo-Iranian Oil Co. Ltd., during 1947 amounted to 20,194,838 tons. For the first three months of 1948 the total production is 5,152,000 tons.

Booklets recently issued by the Anglo-Iranian Oil Co. Ltd. are entitled *The Anglo-Iranian Oil Company in Iran*, and *A Short History of the Anglo-Iranian Oil Company*. Both are profusely illustrated.

H. K. Lewis & Co. Ltd., of 136 Gower Street, London, W.C.1., have just issued their 1948 catalogue of *Books on Chemistry and the Chemical Industry*.

"OIL"

This new publication made its appearance in March and is issued by the Public Relations Department of the M.O.R. Group of Companies. It is planned to be "of service not only to members of the Group but also to all those who are interested in the development of petroleum". Editor is D. Brook Hart and price is 1*s.* per issue.

OIL HOSE

B.S. 1435: 1948 for oil suction and discharge hose for use in the petroleum industry will shortly be available from the British Standards Institution, *price* 2*s.*

The photographs of Canadian drilling reproduced on p. 175 were kindly loaned by the Petroleum Information Bureau.

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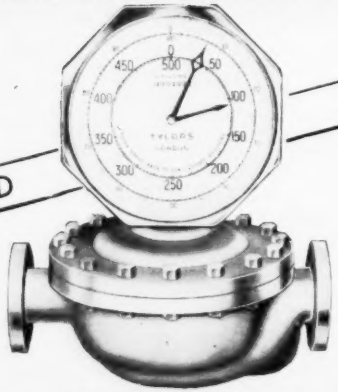

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VISIT OF DR RUF

During June a visit was made to Britain by Dr H. Ruf, assistant manager of the Eidgenossische Material Prüfüngsamt (Swiss Federal Institute for Testing Materials). E.M.P.A. corresponds broadly to the National Physical Laboratory here, though in addition they are responsible for writing Swiss Government Specifications.

It was felt that this would be a convenient opportunity to further the cause of international standardization. Owing to the short notice available it was not possible to arrange for a full meeting of the Standardization Committee, but Dr Ruf attended a meeting of the Chairmen of Sub-Committees of the Standardization Committee on Friday, June 11, at which the work of the Sub-Committees and Panels was discussed. Dr Ruf indicated that it was the policy of E.M.P.A. to adopt Institute of Petroleum and A.S.T.M. methods as far as possible.

CHEMICAL ENGINEERING AT DURHAM UNIVERSITY

Commencing in October, 1948, King's College, Newcastle-upon-Tyne, will offer a two-year post-graduate course in chemical engineering leading to the degree of Master of Science in Chemical Engineering of the University of Durham. The course will be available to graduates in mechanical engineering or to those who possess some equivalent degree or qualification. The opportunity has been taken to link with chemical engineering the teaching of fuel technology which has hitherto been carried out by individual departments as required. Lecturers in chemical engineering and fuel technology have been appointed and the additional teaching in chemistry and engineering subjects required for the new course will be provided by the respective departments.

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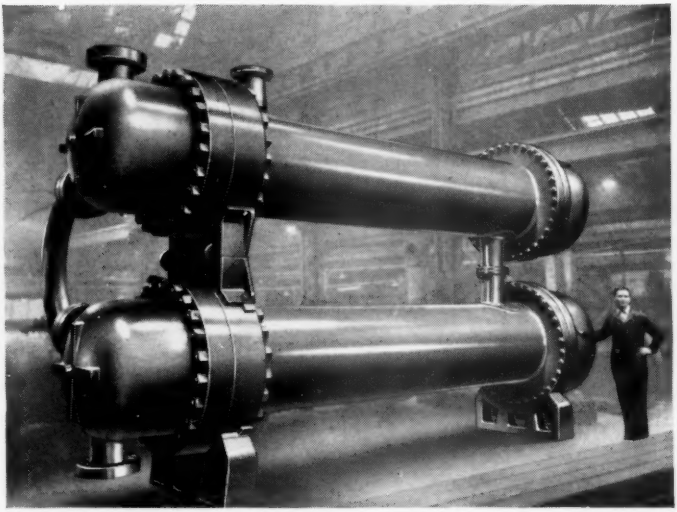

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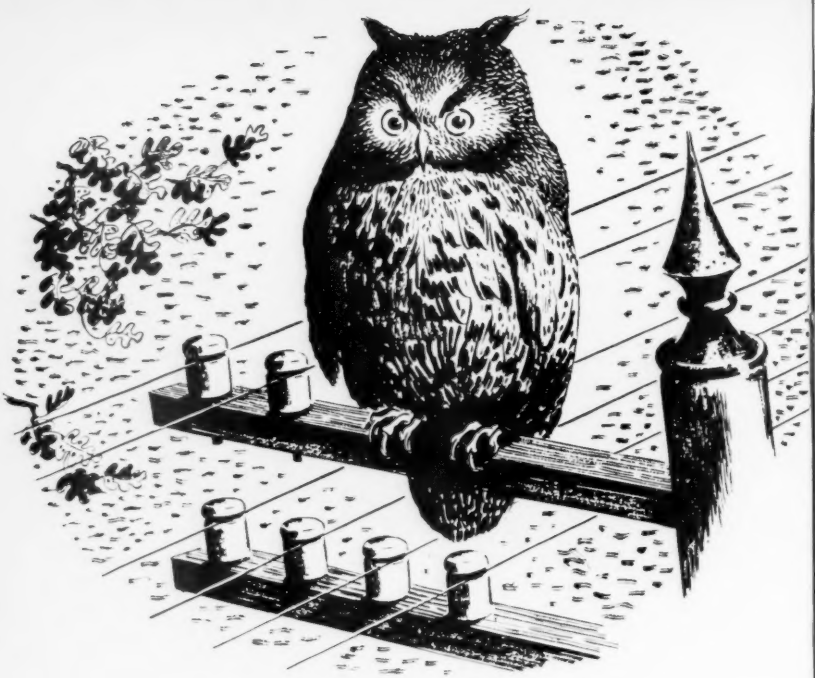

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